



# UL 2202

## STANDARD FOR SAFETY

### DC Charging Equipment for Electric Vehicles

[ULNORM.COM](https://www.ulnorm.com) : Click to view the full PDF of UL 2202 2022

[ULNORM.COM](https://ULNORM.COM) : Click to view the full PDF of UL 2202 2022

UL Standard for Safety for DC Charging Equipment for Electric Vehicles, UL 2202

Third Edition, Dated December 15, 2022

### **Summary of Topics**

***This Third Edition of ANSI/UL 2202 dated December 15, 2022 reflects the trinational standard for Canada, Mexico, and the United States.***

The requirements are substantially in accordance with Proposal(s) on this subject dated November 19, 2021.

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form by any means, electronic, mechanical photocopying, recording, or otherwise without prior permission of UL.

UL provides this Standard "as is" without warranty of any kind, either expressed or implied, including but not limited to, the implied warranties of merchantability or fitness for any purpose.

In no event will UL be liable for any special, incidental, consequential, indirect or similar damages, including loss of profits, lost savings, loss of data, or any other damages arising out of the use of or the inability to use this Standard, even if UL or an authorized UL representative has been advised of the possibility of such damage. In no event shall UL's liability for any damage ever exceed the price paid for this Standard, regardless of the form of the claim.

Users of the electronic versions of UL's Standards for Safety agree to defend, indemnify, and hold UL harmless from and against any loss, expense, liability, damage, claim, or judgment (including reasonable attorney's fees) resulting from any error or deviation introduced while purchaser is storing an electronic Standard on the purchaser's computer system.

ULNORM.COM : Click to buy the full PDF of UL 2202 2022

No Text on This Page

[ULNORM.COM](https://ulnorm.com) : Click to view the full PDF of UL 2202 2022



Association of Standardization and Certification  
NMX-J-817-ANCE-2022  
First Edition



CSA Group  
CSA C22.2 No. 346:22  
First Edition



Underwriters Laboratories Inc.  
UL 2202  
Third Edition

## DC Charging Equipment for Electric Vehicles

December 15, 2022

ULNORM.COM : Click to view the full PDF of UL 2202 2022



## **Commitment for Amendments**

This standard is issued jointly by the Association of Standardization and Certification (ANCE), the Canadian Standards Association (operating as "CSA Group"), and Underwriters Laboratories Inc. (UL). Comments or proposals for revisions on any part of the standard may be submitted to ANCE, CSA Group, or UL at anytime. Revisions to this standard will be made only after processing according to the standards development procedures of ANCE, CSA Group, and UL. CSA Group and UL will issue revisions to this standard by means of a new edition or revised or additional pages bearing their date of issue. ANCE will incorporate the same revisions into a new edition of the standard bearing the same date of issue as the CSA Group and UL pages.

---

## **Copyright © 2022 ANCE**

Rights reserved in favor of ANCE.

---

## **ISBN 978-1-4883-3770-3 © 2022 Canadian Standards Association**

All rights reserved. No part of this publication may be reproduced in any form whatsoever without the prior permission of the publisher.

This Standard is subject to review within five years from the date of publication, and suggestions for its improvement will be referred to the appropriate committee. To submit a proposal for change, please send the following information to [inquiries@csagroup.org](mailto:inquiries@csagroup.org) and include "Proposal for change" in the subject line: Standard designation (number); relevant clause, table, and/or figure number; wording of the proposed change; and rationale for the change.

To purchase CSA Group Standards and related publications, visit CSA Group's Online Store at [www.csagroup.org/store/](http://www.csagroup.org/store/) or call toll-free 1-800-463-6727 or 416-747-4044.

---

## **Copyright © 2022 Underwriters Laboratories Inc.**

UL's Standards for Safety are copyrighted by UL. Neither a printed nor electronic copy of a Standard should be altered in any way. All of UL's Standards and all copyrights, ownerships, and rights regarding those Standards shall remain the sole and exclusive property of UL.

This ANSI/UL Standard for Safety consists of the Third Edition. The most recent designation of ANSI/UL 2202 as an American National Standard (ANSI) occurred on December 15, 2022. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page (front and back), or the Preface.

Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at <https://csds.ul.com>.

To purchase UL Standards, visit UL's Standards Sales Site at <http://www.shopulstandards.com/HowToOrder.aspx> or call toll-free 1-888-853-3503.

---

**CONTENTS**

**PREFACE** ..... 7

**INTRODUCTION**

1 Scope ..... 9  
 2 Glossary ..... 9  
 3 Components ..... 12  
 4 Units of measurement ..... 12  
 5 Normative References ..... 12

**CONSTRUCTION**

6 Ratings ..... 13  
 7 Frame and Enclosure ..... 13  
     7.1 General ..... 13  
     7.2 Access covers ..... 13  
     7.3 Cast metal enclosures ..... 14  
     7.4 Sheet metal enclosures ..... 14  
     7.5 Nonmetallic enclosures ..... 17  
     7.6 Glass covered openings ..... 18  
     7.7 Openings for wiring ..... 18  
     7.8 Openings in an enclosure ..... 19  
     7.9 Enclosure bottom openings ..... 19  
     7.10 Enclosure top openings ..... 21  
     7.11 Enclosures for wet and damp locations ..... 22  
 8 Protection of Users – Accessibility and User Servicing ..... 24  
     8.1 General ..... 24  
     8.2 User servicing ..... 27  
 9 Electric Shock ..... 27  
     9.1 Personnel protection systems ..... 27  
     9.2 Stored energy ..... 28  
 10 Mounting ..... 29  
 11 Corrosion Protection ..... 30  
 12 Mechanical Assembly ..... 32  
 13 Switches and Controls ..... 33  
 14 Supply Connections ..... 33  
     14.1 Permanently connected units ..... 33  
     14.2 Openings for conduit or cable connection ..... 36  
     14.3 Openings for Class 2 circuit conductors ..... 36  
     14.4 Cord-connected units ..... 37  
     14.5 Strain relief ..... 38  
     14.6 Bushings ..... 38  
     14.7 Identification ..... 38  
 15 Wire Bending Space ..... 38  
 16 External Connections and Wiring ..... 42  
     16.1 Output Cable to the electric vehicle ..... 42  
     16.2 Ventilation connections ..... 43  
 17 EV Bonding ..... 43  
 18 Equipment Bonding/Grounding ..... 43  
     18.1 Input circuits ..... 43  
 19 Bonding of Internal Parts ..... 45  
 20 Internal Wiring ..... 47  
     20.1 Wires ..... 47

	20.2 Protection of wiring .....	48
21	Current-Carrying Parts.....	48
	21.1 General.....	48
	21.2 Bus bars .....	49
	21.3 Live heat sinks.....	51
22	Electrical Connections .....	51
23	Spacings .....	52
	23.1 General.....	52
	23.2 Insulation barriers .....	55
24	Alternate Spacings – Clearances and Creepage Distances .....	56
25	Control Circuits .....	56
26	Accessible Signal Circuits .....	58
27	Transformers .....	58
	27.1 General.....	58
	27.2 Coil insulation.....	59
28	Separation of Circuits .....	61
	28.1 Factory wiring .....	61
	28.2 Separation barriers .....	61
	28.3 Field wiring .....	62
29	Overcurrent Protection.....	63
	29.1 General.....	63
	29.2 Supplementary protectors .....	63
	29.3 Thermal links.....	63
	29.4 Fuses .....	63
	29.5 Circuit breakers .....	64
30	Capacitors .....	64
31	Resistors .....	65
32	Lampholders.....	65
33	Printed Wiring Boards.....	65
34	Insulating Materials .....	66
35	Adhesives.....	66
36	Protection of Service Personnel.....	66
37	Electronic Protection Circuits.....	67

## PROTECTION OF USERS AGAINST INJURY

38	General .....	68
39	Sharp Edges.....	69
40	Enclosures and Guards .....	69
41	Strength of Materials .....	70
42	Stability .....	70
43	Mounting Means .....	70
44	Strength of Handles.....	70

## PERFORMANCE

45	General .....	70
46	Leakage Current Test .....	71
47	Leakage Current Test Following Humidity Conditioning .....	75
48	Power Verification Test .....	75
49	Temperature Test .....	75
50	Dielectric Voltage-Withstand Test .....	79
	50.1 General.....	79
	50.2 Maximum-voltage measurements .....	80
	50.3 AC and DC power circuits.....	80

50.4	Secondary circuits .....	81
50.5	Induced potential .....	81
51	Volt-Ampere Capacity Measurement.....	81
52	Abnormal Tests .....	82
52.1	General.....	82
52.2	Transformer burnout test .....	83
52.3	Transformer overload test.....	85
52.4	Short circuit test.....	85
52.5	Capacitor fault test.....	86
52.6	Forced ventilation test .....	86
52.7	Component short- and open-circuit test .....	86
52.8	Electrolytic capacitor fault test.....	86
53	Flanged Bobbin Transformer Abnormal Test.....	86
54	Strain Relief Tests .....	88
54.1	General.....	88
54.2	Strain relief – pull test.....	89
54.3	Strain relief – push back test.....	89
55	Flexing .....	89
56	EV Cable Secureness Test.....	89
57	Grounding Tests .....	90
57.1	Grounding impedance test.....	90
57.2	Bonding/Grounding continuity test.....	90
58	Overcurrent Protection Calibration Test.....	91
59	Strength of Terminal Insulating Base and Support Test .....	91
60	Bonding Conductor Connection Test .....	91
61	Glass Covered Openings Impact Test .....	92
62	Evaluation of Reduced Spacings on Printed-Wiring Boards .....	93
62.1	General.....	93
62.2	Shorted trace test .....	93
63	Heat Sink Temperature Cycling Test .....	93
64	Tests for Permanence of Cord Tag.....	93
64.1	General.....	93
64.2	Test conditions .....	94
64.3	Test method .....	94
65	Tests on Transformer Insulating Materials .....	94
66	Bus Bar Tests.....	94
67	Harmonic Distortion Test.....	95
68	Impact Test.....	96
69	Drop Test.....	96
70	Stability Tests.....	96
71	Static Load Test .....	97
72	Strength of Handles Test.....	97
73	Accelerated Aging Tests of Supporting Feet .....	97

**MANUFACTURING AND PRODUCTION TESTS**

74	Production-Line Dielectric Voltage-Withstand Test .....	98
75	Production-Line Bonding/Grounding-Continuity Test .....	100

**MARKING**

76	Details.....	100
76.1	General.....	100
76.2	Content.....	100
76.3	Cautionary markings.....	105

76.4 Wet and damp location-use markings.....	107
--	-----

## INSTRUCTIONS

77 Instruction Manual.....	107
78 Important Safety Instructions.....	108
79 Assembly Instructions.....	113
80 Operating Instructions.....	113
81 Maintenance Instructions.....	114
82 Moving and Storage Instructions.....	114

## ANNEX A (Normative) – REFERENCED STANDARDS

## ANNEX B (Normative for Canada and Mexico and Informative for the US) – FRENCH AND SPANISH TRANSLATIONS

## ANNEX C (Normative) – LIQUID COOLED CHARGER SYSTEMS

### INTRODUCTION

C1 Scope.....	123
C2 Glossary.....	123

### CONSTRUCTION

C3 General.....	123
C4 External Connections and Wiring.....	124
C5 Risk Assessment.....	124
C6 Functional Safety Evaluation.....	126
C7 Components.....	126
C8 Marking.....	127

ULNORM.COM : Click to view the full PDF of UL 2202:2022

## PREFACE

This is the harmonized ANCE, CSA Group, and UL standard for DC Charging Equipment for Electric Vehicles. It is the first edition of NMX-J-817-ANCE, the first edition of CSA C22.2 No. 346, and the third edition of UL 2202. This edition of UL 2202 supersedes the previous edition(s) published on October 2, 2009, titled Electric Vehicle (EV) Charging System Equipment.

This harmonized standard was prepared by the Association of Standardization and Certification, (ANCE), CSA Group and Underwriters Laboratories Inc. (UL). The efforts and support of the Technical Harmonization Committee for Electric Vehicle Supply Equipment of the Harmonization of Electrotechnical Standards of the Nations of the Americas (CANENA) are gratefully acknowledged.

This standard is considered suitable for use for conformity assessment within the stated scope of the standard.

The present Mexican standard was developed by the GT CONANCE from the Comité de Normalización de la Asociación de Normalización y Certificación, A.C., CONANCE, with the collaboration of different type of manufacturers and users.

This standard was reviewed by the CSA Subcommittee on DC Fast Charging System for Electric Vehicles, under the jurisdiction of the CSA Technical Committee on Industrial Products and the CSA Strategic Steering Committee on Requirements on Electrical Safety, and has been formally approved by the CSA Technical Committee. This standard has been developed in compliance with Standards Council of Canada requirements for National Standards of Canada. It has been published as a National Standard of Canada by CSA Group.

### Application of Standard

Where reference is made to a specific number of samples to be tested, the specified number is to be considered a minimum quantity.

Note: Although the intended primary application of this standard is stated in its scope, it is important to note that it remains the responsibility of the users of the standard to judge its suitability for their particular purpose.

### Level of Harmonization

This standard uses the IEC format but is not based on, nor is it considered equivalent to, an IEC standard.

This standard is published as an equivalent standard for ANCE, CSA Group and UL.

An equivalent standard is a standard that is substantially the same in technical content, except as follows: Technical national differences are allowed for codes and governmental regulations as well as those recognized as being in accordance with NAFTA Article 905, for example, because of fundamental climatic, geographical, technological, or infrastructural factors, scientific justification, or the level of protection that the country considers appropriate. Presentation is word for word except for editorial changes.

### Reasons for Differences From IEC

This standard provides general requirements for electric vehicle supply equipment for use in accordance with the electrical installation codes of Canada, Mexico, and the United States. At present there is no IEC standard for these products for use in accordance with these codes. Therefore, this standard does not employ any IEC standard for base requirements.

## Interpretations

The interpretation by the standards development organization of an identical or equivalent standard is based on the literal text to determine compliance with the standard in accordance with the procedural rules of the standards development organization. If more than one interpretation of the literal text has been identified, a revision is to be proposed as soon as possible to each of the standards development organizations to more accurately reflect the intent.

ULNORM.COM : Click to view the full PDF of UL 2202 2022

# DC Charging Equipment for Electric Vehicles

## INTRODUCTION

### 1 Scope

1.1 These requirements apply to DC conductive charging equipment intended to be supplied with a maximum input voltage of 1000 V ac or 1500 V dc, for recharging the propulsion batteries in over-the-road electric vehicles (EV). DC charging equipment for EV installations are intended for either:

- a) Dry location only, or
- b) Dry, wet, and damp location.

Equipment is intended to be installed in accordance with the Installation Codes in Annex A, Ref. No. 1.

1.2 The output of the DC charging equipment for EV shall not exceed 1500 V dc.

1.3 For the purposes of this Standard, the term "electric vehicle" designated throughout by the initials "EV", is considered to cover electric vehicles, hybrid electric vehicles, and plug-in versions of these vehicles.

1.4 DC charging equipment for EV that is not a complete assembly and depends upon installation in an end product for compliance with the requirements in this Standard is investigated under the requirements of this Standard and the standard for the end product.

1.5 These requirements do not cover battery chargers covered by Annex A, Ref. Nos. 2 and 3.

1.6 These requirements do not cover on-board chargers.

1.7 These requirements do not cover electric vehicle supply equipment covered by Annex A, Ref. No. 4.

1.8 These requirements do not cover DC charging equipment for EV intended to be used in hazardous locations, such as near fuel dispensing stations.

### 2 Glossary

2.1 In the text of this Standard, the term "unit" refers to any product covered by this standard. The letters "EV" refers to an electric vehicle, a hybrid electric vehicle, or plug-in versions of these vehicles in accordance with 1.2. For the purpose of this Standard, the following definitions apply.

2.2 ACCESSIBLE PART – A part so located that it is capable of being contacted by a person, either directly or by means of an accessibility probe.

2.3 BARRIER – A part inside an enclosure that reduces access to a part that involves a risk of fire, electric shock, injury to persons, or electrical energy – high current levels.

2.4 BASIC INSULATION – The insulation required for the proper functioning of a device, and for basic protection against electrical hazard.

2.5 BONDED (BONDING) – The permanent joining of metallic parts to form an electrically conductive path that provides electrical continuity and the capacity to conduct any current likely to be imposed without a risk of electric shock or fire.

2.6 BRANCH CIRCUIT – The portion of the building wiring system beyond the final overcurrent protective device on the power-distribution panel that protects the circuit to the field-wiring terminals in a permanently connected unit or to the receptacle outlet for a cord-connected unit.

2.7 CELL – Two electrodes of dissimilar material separated from one another by a common ionically conductive electrolyte, that are intended to convert chemical energy directly into electrical energy.

2.8 CLASS 2 TRANSFORMER – A step-down transformer complying with the applicable requirements in:

- a) Annex [A](#), Ref. Nos. 4 and 5; or
- b) Annex [A](#), Ref. No. 6.

2.9 CONTROL CIRCUIT – A circuit that carries electric signals but not main power current.

2.10 ELECTRIC VEHICLE (EV) – An over-the-road automotive-type vehicle for highway use, such as a passenger automobile, bus, truck, van, motorcycle, or similar vehicle, which receives primary or supplementary propulsion power from an electric motor that draws current from a rechargeable storage battery.

2.11 ELECTROLYTE – A semisolid, liquid, or aqueous salt solution that makes ionic conduction between positive and negative electrodes of a cell possible.

2.12 ENCLOSURE – A surrounding case constructed to provide a degree of protection to personnel against access to hazardous parts and to provide a degree of protection to the enclosed equipment against specified environmental conditions.

2.13 EXPOSED – Visible and able to be contacted by an accessibility probe.

2.14 FASTENED IN PLACE – A mounting means for equipment which is specifically designed to permit periodic removal of the equipment for relocation, interchangeability, maintenance, or repair without the use of a tool.

2.15 FIELD-WIRING LEAD – Any lead to which a supply, load, or other wire is intended be connected by an installer.

2.16 FIELD-WIRING TERMINAL – A terminal to which a supply, load, or other wire is intended to be connected by an installer.

2.17 FIXED IN PLACE – A mounting means for equipment that requires a tool to remove the equipment from its mounted position.

2.18 GROUND – A conducting connection, whether intentional or accidental, between an electrical circuit or equipment and the earth or to some conducting body that serves in place of the earth.

2.19 GUARD – A part that reduces access to a component that results in a risk of injury to persons. See Enclosures and Guards, Section [40](#).

2.20 INSULATION, SUPPLEMENTARY – An independent insulation provided in addition to the basic insulation to protect against the risk of electric shock in the event.

2.21 LEAKAGE CURRENT – Electric current which flows through a person upon contact, between accessible parts of a unit and:

- a) Ground, or
- b) Other accessible parts of the unit.

2.22 LIMITED-ENERGY CIRCUIT – An ac or dc circuit having a voltage not exceeding 1000 volts and the energy limited to 100 volt-amperes by either a secondary winding of a transformer, one or more resistors complying with [25.10](#), or a regulating network complying with [25.11](#).

2.23 LIVE PART – A conductive part, such as metal, within the unit that during intended use has a potential difference with respect to earth ground or any other conductive part.

2.24 LOW-VOLTAGE, LIMITED-ENERGY (LVLE) CIRCUIT – A circuit involving an alternating current voltage of not more than 30 volts, rms (42.4 volts peak) or a direct current voltage of not more than 60 volts and supplied by:

- a) An inherently limited Class 2 transformer or power unit or a not inherently limited Class 2 transformer or power unit and an overcurrent protective device that is:
  - 1) Not of the automatic reclosing type,
  - 2) Trip-free from the reclosing mechanism, and
  - 3) Either not readily interchangeable with a device of a different rating or a marking in accordance with [76.3.8](#) is provided; or
- b) A combination of an isolated transformer secondary winding and one or more resistors or a regulating network complying with [25.11](#) that complies with all the performance requirements for an inherently limited Class 2 transformer or power source.

2.25 MEASUREMENT INDICATION UNIT (MIU) – The output voltage across the meter, in millivolts rms, in the measurement instrument in [Figure 46.3](#), divided by 500 ohms. (The instrument indication is equal to the rms value in milliamperes when the frequency is 60 Hz (sinusoidal current). The reading is not always a direct indication of the rms or other common amplitude quantifier of leakage current when the leakage current is of complex waveform or frequency other than 50 or 60 Hz.)

2.26 PORTABLE UNIT – A unit that has no provisions for permanent mounting or wiring, and is easily carried or conveyed by hand and whose input rating does not exceed 16 ampere, 120 V ac.

2.27 PRESSURE TERMINAL CONNECTOR – A field wiring terminal that accomplishes the connection of one or more conductors by means of pressure without the use of solder. Examples of pressure terminal connectors are barrel and setscrew type, crimp-type barrel, and clamping plate and screw type.

2.28 PRIMARY CIRCUIT – Wiring and components that are conductively connected to a branch circuit.

2.29 RISK OF ELECTRICAL ENERGY – HIGH CURRENT LEVELS – The risk of damage to property or injury to persons, other than by electric shock, from available electrical energy exists when between a live part and an adjacent dead metal part or between live parts of different polarity, there exists a potential of 2 volts or more and either an available continuous power level of 240 volt-amperes or more, or a reactive energy level of 20 joules or more.

2.30 SAFETY CIRCUIT – Any primary or secondary circuit that is used to reduce the risk of fire, electric shock, injury to persons, or electrical energy- high current levels. For example, in some applications, an interlock circuit is considered to be a safety circuit.

2.31 SECONDARY CIRCUIT – A circuit supplied from a secondary winding of an isolating transformer. See [27.1.3](#).

2.32 SERVICE PERSONNEL – Trained persons having familiarity with the construction and operation of the equipment and the risks involved.

2.33 TOOL – A screwdriver, coin, key, or any other object that is used to operate a screw, latch, or similar fastening means.

### 3 Components

3.1 A component of a product covered by this Standard shall:

- a) Comply with the requirements for that component as specified in this Standard. A component shall comply with the ANCE, CSA, or UL standards as appropriate for the country where the product is to be used.
- b) Be used in accordance with its rating(s) established for the intended conditions of use; and
- c) Be used within its established use limitations or conditions of acceptability.

3.2 A component of a product covered by this Standard is not required to comply with a specific component requirement that:

- a) Involves a feature or characteristic not required in the application of the component in the product;
- b) Is superseded by a requirement in this Standard; or
- c) Is separately investigated when forming part of another component, provided the component is used within its established ratings and limitations.

3.3 Specific components are incomplete in construction features or restricted in performance capabilities. Such components are intended for use only under limited conditions, such as certain temperatures not exceeding specified limits, and shall be used only under those specific conditions.

3.4 A component that is also intended to perform other functions such as overcurrent protection, ground-fault circuit-interruption, surge suppression, any other similar functions, or any combination thereof, shall comply additionally with the requirements of the applicable ANCE, CSA, or UL standard(s) that cover devices that provide those functions.

### 4 Units of measurement

4.1 The values given in SI (metric) units shall be normative. Any other values given shall be for information purposes only.

### 5 Normative References

5.1 Where reference is made to any Standard, such reference shall be considered to refer to the latest editions and revisions thereto available at the time of printing, unless otherwise specified.

5.2 Products covered by this Standard shall comply with the reference installation codes and Standards noted in Annex A as appropriate for the country where the product is to be used. When the product is intended for use in more than one country, the product shall comply with the installation codes and Standards for all countries where it is intended to be used.

5.3 For products intended for use in Canada, general requirements are given in Annex A, Ref. No. 8. In Mexico and the United States, this does not apply.

## CONSTRUCTION

### 6 Ratings

6.1 A unit shall have the following ratings:

- a) Input rating in volts, number of phases, frequency, and amperes; and
- b) Output rating in volts dc and amperes.

### 7 Frame and Enclosure

#### 7.1 General

7.1.1 Except as noted in [7.1.2](#), a unit shall be provided with one or more enclosures that house all live parts. The enclosure shall be formed and assembled so that it has the strength and rigidity to resist the abuses to which it may be subjected to in use without resulting in a risk of fire or electric shock due to total or partial collapse with resulting reduction in spacings, loosening or displacement of parts, or other defects. The parts of the enclosure that are required to be in place to comply with the requirements for risk of fire, electric shock, injury to persons, and electrical energy – high current levels shall comply with the applicable enclosure requirements specified in this standard.

7.1.2 Live parts, including terminals, that do not present a risk of electric shock or a risk of electrical energy – high current levels, are not required to be enclosed.

7.1.3 The frame or chassis of a unit shall not be used to carry current during intended operation.

7.1.4 A part, such as a dial, display face, or nameplate, that serves as a functional part of the enclosure shall comply with the enclosure requirements.

7.1.5 Except as noted in [7.1.6](#), when an electrical instrument, such as a meter, forms part of the enclosure, the face or the back of the instrument housing, or both together, shall comply with the requirements for an enclosure.

7.1.6 A meter complying with the requirements in Annex A, Ref. No. 9 is not required to comply.

#### 7.2 Access covers

7.2.1 Except as noted in [7.2.2](#), an access cover shall be hinged where it gives access to a fuse or other overload-protective device, the functioning of which requires renewal or resetting, or where it is required to open the cover in connection with intended operation of the unit. A means shall be provided to hold the cover positively closed.

7.2.2 A hinged cover is not required when the only overload-protective device enclosed is:

- a) Connected in a control circuit, where the protective device and the circuit loads are within the same enclosure,
- b) Rated 2 amperes or less for loads not exceeding 100 volt-amperes,
- c) An extractor fuse having an integral enclosure, or
- d) Connected in a low-voltage, limited-energy circuit.

7.2.3 A door or cover giving access to a fuse shall be tight-fitting.

### 7.3 Cast metal enclosures

7.3.1 Except as noted in [7.3.2](#), the thickness of cast metal for an enclosure shall be as specified in [Table 7.1](#).

7.3.2 Die-cast metal and cast metal of a lesser thickness is employed when upon investigation (taken into account the shape, size, and function of the enclosure) it is found to have equivalent mechanical strength for the intended use.

**Table 7.1**  
**Thickness of Cast-Metal Enclosures**

Use, or dimension of area involved	Minimum thickness, mm (inch)	
	Die-cast metal	Cast metal of other than the die-cast type
Area of 154.8 cm <sup>2</sup> (24 square inches) or less and having no dimension greater than 152 mm (6 inches)	1.6 (1/16 <sup>a</sup> )	3.2 (1/8)
Area greater than 154.8 cm <sup>2</sup> (24 square inches) or having any dimension greater than 152 mm (6 inches)	2.4 (3/32)	3.2 (1/8)
At a threaded conduit hole	6.4 (1/4)	6.4 (1/4)
At an unthreaded conduit hole	3.2 (1/8)	3.2 (1/8)

<sup>a</sup> The area limitation for metal 1.6 mm (1/16 inch) thick is obtained by the provision of reinforcing ribs subdividing a larger area.

### 7.4 Sheet metal enclosures

7.4.1 Sheet metal enclosures shall comply with the requirements in Annex [A](#), Ref. No. 10 or [7.4.2](#).

7.4.2 With reference to [7.4.1](#), the thickness of a sheet-metal enclosure shall not be less than that specified in [Table 7.2](#) and [Table 7.3](#). Uncoated steel shall not be less than 0.81 mm (0.032 inch) thick, zinc-coated steel shall not be less than 0.86 mm (0.034 inch) thick, and nonferrous metal shall not be less than 1.14 mm (0.045 inch) thick for surfaces of an enclosure at which a wiring system is to be connected. A part of the enclosure that complies with the Mechanical Strength Tests for Metal Enclosures as specified in Annex [A](#), Ref. No. 11, is not required to comply with the thickness specified in [Table 7.2](#) and [Table 7.3](#).

**Table 7.2**  
**Thickness of Carbon Steel or Stainless Steel Enclosures**

Without supporting frame <sup>a</sup>		With supporting frame or equivalent reinforcing <sup>a</sup>				Minimum thickness mm (inch)					
Maximum width <sup>b</sup>		Maximum length <sup>c</sup>		Maximum width <sup>b</sup>		Maximum length		Uncoated		Metal coated	
cm	(inches)	cm	(inches)	cm	(inches)	cm	(inches)				
10.2	(4.0)	Not limited		15.9	(6.25)	Not limited		0.51	(0.020) <sup>d</sup>	0.58	(0.023) <sup>d</sup>
12.1	(4.75)	14.6	(5.75)	17.1	(6.75)	21.0 (8.25)					
15.2	(6.0)	Not limited		24.1	(9.5)	Not limited		0.66	(0.026) <sup>d</sup>	0.74	(0.029) <sup>d</sup>
17.8	(7.0)	22.2	(8.75)	25.4	(10.0)	31.8 (12.5)					
20.3	(8.0)	Not limited		30.5	(12.0)	Not limited		0.81	(0.032)	0.86	(0.034)
22.9	(9.0)	29.2	(11.5)	33.0	(13.0)	40.6 (16.0)					
31.8	(12.5)	Not limited		49.5	(19.5)	Not limited		1.07	(0.042)	1.14	(0.045)
35.6	(14.0)	45.7	(18.0)	53.3	(21.0)	63.5 (25.0)					
45.7	(18.0)	Not limited		68.6	(27.0)	Not limited		1.35	(0.053)	1.42	(0.056)
50.8	(20.0)	63.5	(25.0)	73.7	(29.0)	91.4 (36.0)					
55.9	(22.0)	Not limited		83.8	(33.0)	Not limited		1.52	(0.060)	1.60	(0.063)
63.5	(25.0)	78.7	(31.0)	88.9	(35.0)	109.2 (43.0)					
63.5	(25.0)	Not limited		99.1	(39.0)	Not limited		1.70	(0.067)	1.78	(0.070)
73.7	(29.0)	91.4	(36.0)	104.1	(41.0)	129.5 (51.0)					
83.8	(33.0)	Not limited		129.5	(51.0)	Not limited		2.03	(0.080)	2.13	(0.084)
103.4	(38.0)	119.4	(47.0)	137.2	(54.0)	167.6 (66.0)					
106.7	(42.0)	Not limited		162.6	(64.0)	Not limited		2.36	(0.093)	2.46	(0.097)
119.4	(47.0)	149.9	(59.0)	172.7	(68.0)	213.4 (84.0)					
132.1	(52.0)	Not limited		203.2	(80.0)	Not limited		2.74	(0.108)	2.82	(0.111)
152.4	(60.0)	188.0	(74.0)	213.4	(84.0)	261.6 (103.0)					
160.0	(63.0)	Not limited		246.4	(97.0)	Not limited		3.12	(0.123)	3.20	(0.126)
185.4	(73.0)	228.6	(90.0)	261.6	(103.0)	322.6 (127.0)					

<sup>a</sup> See 7.4.4 and 7.4.5.

<sup>b</sup> The width is the smaller dimension of a rectangular sheet metal piece that is part of an enclosure. Adjacent surfaces of an enclosure may have supports in common and be made of a single sheet.

<sup>c</sup> "Not limited" applies only when the edge of the surface is flanged at least 12.7 mm (1/2 inch) or fastened to adjacent surfaces not normally removed in use.

<sup>d</sup> Sheet steel for an enclosure intended for use in wet and damp locations shall not be less than 0.86 mm (0.034 inch) thick when metal coated and not less than 0.81 mm (0.032 inch) thick when uncoated.

**Table 7.3**  
**Thickness of Aluminum, Copper, or Brass Enclosures**

Without supporting frame <sup>a</sup>		With supporting frame or equivalent reinforcing <sup>a</sup>		Minimum thickness mm
Maximum width <sup>b</sup>		Maximum length <sup>c</sup>		
cm	(inches)	cm	(inches)	(inches)
7.6	(3.0)	Not limited	17.8 (7.0)	0.58 <sup>d</sup>
8.9	(3.5)	10.2 (4.0)	21.6 (8.5)	(0.023)
10.2	(4.0)	Not limited	25.4 (10.0)	0.74
12.7	(5.0)	15.2 (6.0)	26.7 (10.5)	(0.029)
15.2	(6.0)	Not limited	35.6 (14.0)	0.91
16.5	(6.5)	20.3 (8.0)	38.1 (15.0)	(0.036)
20.3	(8.0)	Not limited	48.3 (19.0)	1.14
24.1	(9.5)	29.2 (11.5)	53.3 (21.0)	(0.045)
30.5	(12.0)	Not limited	71.1 (28.0)	1.47
35.6	(14.0)	40.6 (16.0)	76.2 (30.0)	(0.058)
45.7	(18.0)	Not limited	106.7 (42.0)	1.91
50.8	(20.0)	63.4 (25.0)	114.3 (45.0)	(0.075)
63.4	(25.0)	Not limited	152.4 (60.0)	2.41
73.7	(29.0)	91.4 (36.0)	162.6 (64.0)	(0.095)
94.0	(37.0)	Not limited	221.0 (87.0)	3.10
106.7	(42.0)	134.6 (53.0)	236.2 (93.0)	(0.122)
132.1	(52.0)	Not limited	312.4 (123.0)	3.89
152.4	(60.0)	188.0 (74.0)	330.2 (130.0)	(0.153)

<sup>a</sup> See 7.4.4 and 7.4.5.

<sup>b</sup> The width is the smaller dimension of a rectangular sheet metal piece that is part of an enclosure. Adjacent surfaces of an enclosure may have supports in common and be made of a single sheet.

<sup>c</sup> "Not limited" applies only when the edge of the surface is flanged at least 12.7 mm (1/2 inch) or fastened to adjacent surfaces not normally removed in use.

<sup>d</sup> Sheet copper, brass, or aluminum for an enclosure intended for use in wet and damp locations shall not be less than 0.74 mm (0.029 inch) thick.

7.4.3 [Table 7.2](#) and [Table 7.3](#) are based on a uniform deflection of the enclosure surface for any given load concentrated at the center of the surface regardless of metal thickness.

7.4.4 With reference to [Table 7.2](#) and [Table 7.3](#), a supporting frame is a structure of angle or channel or a folded rigid section of sheet metal that is rigidly attached to and has the same outside dimensions as the enclosure surface and that has the torsional rigidity to resist the bending moments that are applied via the enclosure surface. A construction has equivalent reinforcement when it produces a structure that is as rigid as one built with a frame of angles or channels.

7.4.5 With reference to [7.4.4](#) and [Table 7.2](#) and [Table 7.3](#), a construction does not have a supporting frame when it is:

- a) A single sheet with single formed flanges – formed edges;
- b) A single sheet that is corrugated or ribbed;
- c) An enclosure formed or fabricated from sheet metal; or
- d) An enclosure surface loosely attached to a frame – for example, by spring clips.

## 7.5 Nonmetallic enclosures

7.5.1 A polymeric enclosure or polymeric part of an enclosure shall comply with the requirements in Annex A, Ref. No. 12. See 7.5.2. For units intended for use in wet and damp locations, the material for the enclosure, or part of the enclosure, shall be judged on the basis of the effect of exposure to water and ultraviolet light in accordance with Annex A, Ref. No. 12. See also 7.5.3.

7.5.2 With reference to 7.5.1, for a cord-connected unit that is intended to be supported on a bench, desk, table, or similar apparatus, the flammability requirements for portable equipment specified in Annex A, Ref. No. 12 shall be applied.

7.5.3 Except as noted in 7.5.4, a nonmetallic part that forms part of the enclosure, and is made from a material classed as HB or better, is not required to comply with 7.5.1 under any one of the following conditions:

- a) The nonmetallic part covers an opening that has no dimension greater than 25.4 mm (1 inch);
- b) The nonmetallic part covers an opening which does not allow access to live parts involving a risk of fire, electric shock, or electric energy-high current levels – or moving parts to the user when the nonmetallic part is removed;
- c) The nonmetallic part covers an opening that has no dimension greater than 101.6 mm (4 inches) and there is no source of a risk of fire closer than 101.6 mm (4 inches) from the surface of the enclosure; or
- d) The nonmetallic part with a barrier or a device that forms a barrier made of a material classed V-0 between the nonmetallic part and a source of a risk of fire.

7.5.4 A part of a component is not required to be classed V-0, V-1, V-2, or HB when it complies with the flammability class applicable to the component.

7.5.5 A polymeric material enclosure having in any single unbroken section, a projected surface area greater than 0.93 m<sup>2</sup> (10 square feet) or a single linear dimension greater than 1.83 m (6 feet) shall have a flame-spread rating of 200 or less when tested in accordance with the:

- a) Requirements in Annex A, Ref. No. 13; or
- b) Radiant-panel furnace method in Annex A, Ref. No. 14.

7.5.6 A material with a flame-spread rating higher than specified in 7.5.5 is a usable alternative for the exterior finish or covering on any portion of the enclosure when the flame-spread rating of the combination of the base material and finish or covering complies with 7.5.5.

7.5.7 Except as noted in 7.5.8, a conductive coating applied to a nonmetallic surface (such as the inside surface of a cover or an enclosure) shall comply with the appropriate requirements in Annex A, Ref. No. 12.

7.5.8 Where flaking or peeling of the coating does not result in a risk of fire or electric shock as a result of a reduction of spacings or the bridging of live parts, then the coating is not required to comply with Annex A, Ref. No. 12.

7.5.9 A nonmetallic enclosure intended for connection to a rigid conduit system shall comply with the Polymeric Enclosure Rigid Metallic Conduit Connection Tests in Annex A, Ref. No. 10.

## 7.6 Glass covered openings

7.6.1 Glass covering an opening shall be secured in place so that it is not readily displaced in service, and shall provide mechanical protection for the enclosed parts. Glass for an opening not more than 101.6 mm (4 inches) in any dimension shall not be less than 1.6 mm (1/16 inch) thick, and glass for an opening not more than 929 cm<sup>2</sup> (144 square inches) in area and having no dimension greater than 305 mm (12 inches) shall not be less than 3.2 mm (1/8 inch) thick. Glass used to cover an area larger than specified above shall not be less than 1/8 inch thick and shall:

- a) Be of a non-shattering or tempered type that, when broken, complies with Annex A, Ref. No. 15; or
- b) Be subjected to the test described in [61.1](#).

## 7.7 Openings for wiring

7.7.1 The requirements described in [7.7.2](#) – [7.7.9](#) apply to fixed in place units.

7.7.2 When threads for the connection of conduit are tapped all the way through a hole in an enclosure wall or when an equivalent construction is employed, there shall not be less than three nor more than five threads in the metal, and the construction of the enclosure shall be such that a conduit bushing is capable of being attached as intended. When threads for the connection of conduit are not tapped all the way through a hole in an enclosure wall, conduit hub, or similar material, there shall not be less than 3-1/2 threads in the metal and there shall be a smooth, rounded inlet hole for the conductors equivalent to that provided by a standard conduit bushing with an internal diameter the same as that of the corresponding trade size of rigid conduit.

7.7.3 Clamps and fasteners for the attachment of conduit, electrical metallic tubing, armored cable, nonmetallic flexible tubing, nonmetallic-sheathed cable, service cable, and similar material that are supplied as a part of an enclosure shall comply with Annex A, Ref. Nos. 16 and 17.

7.7.4 A knockout in a sheet-metal enclosure shall be secured and shall be removable without undue deformation of the enclosure.

7.7.5 A knockout shall be provided with a flat surrounding surface so that the conduit bushing is capable of being seated as intended, and shall be located so that installation of a bushing at any knockout to be used during installation does not result in spacing between an uninsulated live part and the bushing to be less than that specified in Spacings, Section [23](#).

7.7.6 In measuring a spacing between an uninsulated live part and a bushing installed in a knockout as mentioned in [7.7.5](#), a bushing having the dimensions specified in [Table 7.4](#) shall be in place, in conjunction with a single locknut installed on the outside of the enclosure.

**Table 7.4**  
**Knockout or Hole Sizes and Dimensions of Bushings**

Metric designator (Trade size)		Knockout or hole diameter		Bushing dimensions			
				Overall diameter		Height	
mm	(inches)	mm	(inches)	mm	(inches)	mm	(inches)
16	(1/2)	22.2	(7/8)	25.4	(1)	9.5	(3/8)
21	(3/4)	27.8	(1-3/32)	31.4	(1-15/64)	10.7	(27/64)
27	(1)	34.5	(1-23/64)	40.5	(1-19/32)	13.1	(33/64)
35	(1-1/4)	43.7	(1-23/32)	49.2	(1-15/16)	14.3	(9/16)
41	(1-1/2)	50.0	(1-31/32)	56.0	(2-13/64)	15.10	(19/32)
53	(2)	62.7	(2-15/32)	68.7	(2-45/64)	15.9	(5/8)
63	(2-1/2)	76.2	(3)	81.8	(3-7/32)	19.1	(3/4)
78	(3)	92.1	(3-5/8)	98.4	(3-7/8)	20.6	(13/16)

7.7.7 For an enclosure not provided with conduit openings or knockouts, spacings not less than the minimum specified in Spacings, Section 23 shall be provided between uninsulated live parts and a conduit bushing installed at any location that is to be used during installation. Permanent marking on the enclosure, a template, or a drawing furnished with the unit are ways to specify such a location. The specified location of the openings shall be such that damage to internal parts does not result when openings are made.

7.7.8 With respect to the requirement in 7.7.7, means shall be provided so that an opening for conduit is capable of being made without subjecting internal parts to contamination resulting from the presence of metallic particles. Compliance with this requirement is possible by the use of a removable, bolted plate.

7.7.9 A polymeric- or metal-closure plug for an unused conduit opening shall comply with Annex A, Ref. No. 16.

## 7.8 Openings in an enclosure

7.8.1 The enclosure of a unit shall be designed and constructed to reduce the risk of emission of flame, molten metal, flaming or glowing particles, or flaming drops from exiting the enclosure and falling on combustible materials outside of the enclosure.

## 7.9 Enclosure bottom openings

7.9.1 Except as noted in 7.9.2 – 7.9.5, the requirement in 7.8.1 requires a complete noncombustible bottom or a construction employing individual noncombustible barriers under components, groups of components, or assemblies, as specified in Figure 7.1.

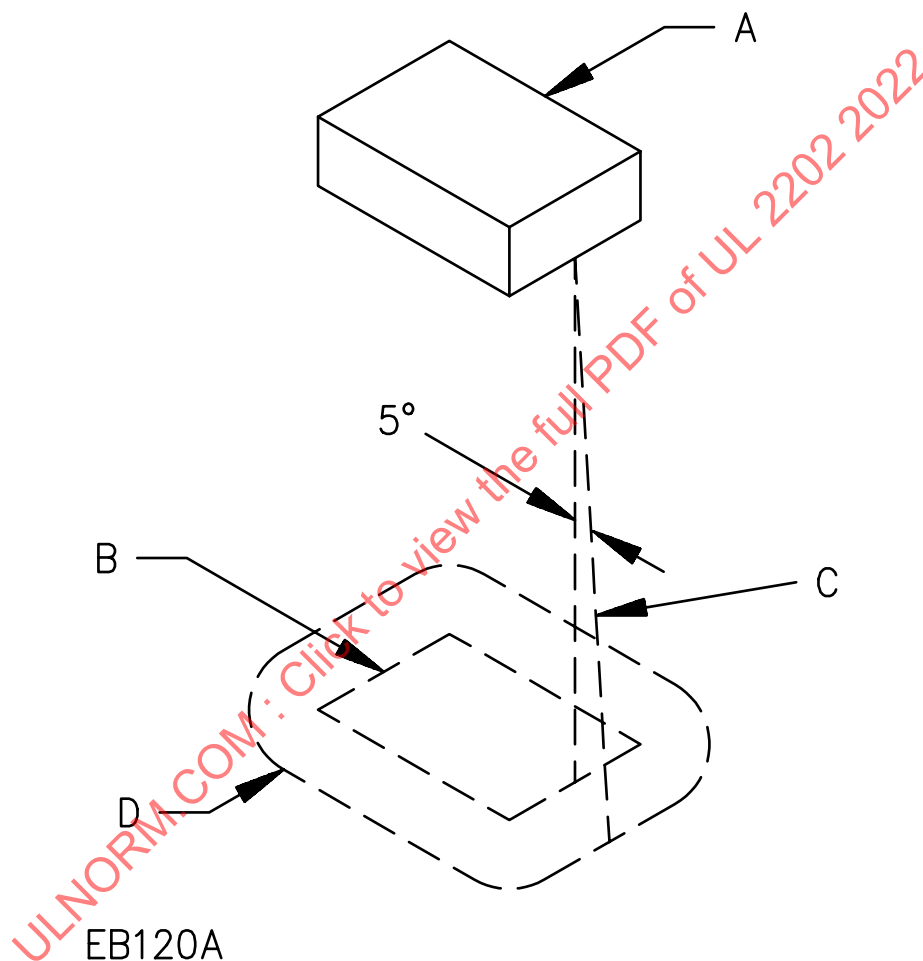
7.9.2 An enclosure may be provided with ventilating openings in the bottom panel when noncombustible baffle plates are provided to reduce the risk of materials from falling directly from the interior of the unit onto the supporting surface or any other location under the unit. An example of such a baffle is illustrated in Figure 7.2.

7.9.3 An enclosure may be provided with ventilation openings in the bottom of an enclosure when the openings incorporate a perforated metal plate as described in Table 7.5, or a galvanized or stainless steel screen having a 25.4-mm (14- by 14-mesh per inch) constructed of wire with a diameter of 0.4 mm (0.018 inch) minimum.

7.9.4 The bottom of the enclosure under areas containing only materials classed V-1 or better in accordance with Annex A, Ref. No. 18, shall have openings no larger than 40 mm<sup>2</sup> (1/16 square inch).

7.9.5 An enclosure may be provided with ventilating openings without limitation on their size and number and complying with 8.1.7 in the bottom panel in areas that contain only wires, cable, plugs, receptacles, transformers, and impedance protected or thermally protected motors, and in areas that contain only capacitors that are described in Section 30.

**Figure 7.1**  
**Enclosure Bottom**



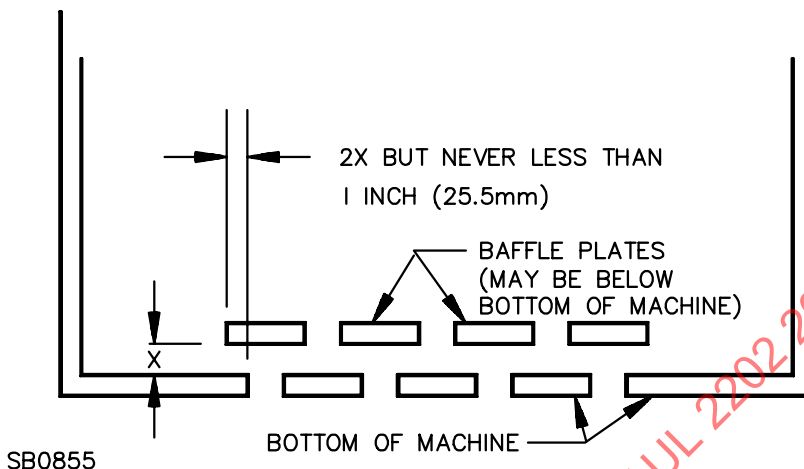
A – Region to be shielded by barrier. This consists of the entire component when it is not otherwise shielded, and of the unshielded portion of a component that is partially shielded by the component enclosure or equivalent.

B – Projection of outline of component on horizontal plane.

C – Inclined line which traces out minimum area of barrier. When moving, the line is always: (1) tangent to the component, (2) five degrees from the vertical, and (3) so oriented that the area traced out on a horizontal plane is maximum.

D – Location (horizontal) and minimum area for barrier. The area is that included inside the line of intersection traced out by the inclined line C and the horizontal plane of the barrier.

**Figure 7.2**  
**Example of a Bottom-Enclosure Baffle**



**Table 7.5**  
**Perforated Metal Plates for Enclosure Bottom**

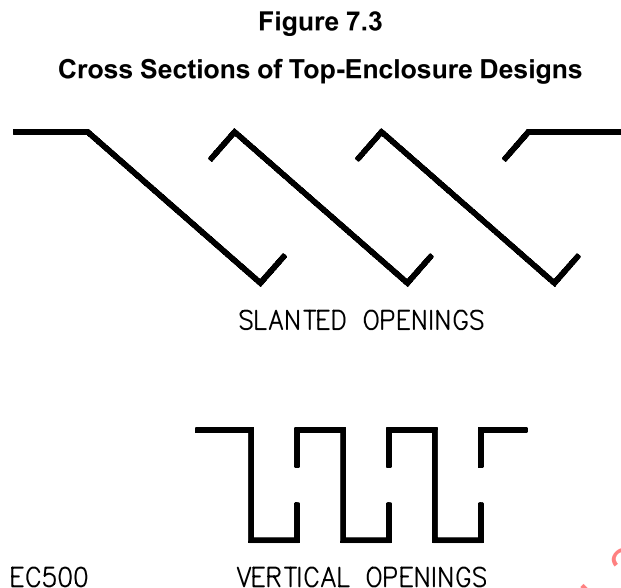
Minimum thickness		Maximum diameter of holes		Minimum spacings of holes center to center	
mm	(inch)	mm	(inch)	mm	(inch)
0.66	(0.026)	1.14	(0.045)	1.70	(0.067)
				645 mm <sup>2</sup>	(233 holes per inch <sup>2</sup> )
0.66	(0.026)	1.19	(0.047)	2.36	(0.093)
0.76	(0.030)	1.14	(0.045)	1.70	(0.067)
0.76	0.030)	1.19	(0.047)	2.36	(0.093)
0.81	(0.032)	1.91	(0.075)	3.18	(0.125)
				645 mm <sup>2</sup>	(72 holes per inch <sup>2</sup> )
0.89	(0.035)	1.90	(0.075)	3.18	(0.125)
0.91	(0.036)	1.60	(0.063)	2.77	(0.109)
0.91	(0.036)	1.98	(0.078)	3.18	(0.125)
0.99	(0.039)	1.60	(0.063)	2.77	(0.109)
0.99	(0.039)	2.00	(0.079)	3.00	(0.118)

NOTE – In accordance with [7.9.3](#).

**7.10 Enclosure top openings**

7.10.1 Except as noted in [7.10.2](#), the minor dimension – see [8.1.6](#) – of any opening in the top of an enclosure directly over an uninsulated live part involving a risk of electric shock or electrical energy – high current levels – shall not exceed 4.8 mm (3/16 inch) unless the configuration is such that the risk of direct vertical entry of a falling object to uninsulated live parts is reduced by means of a trap or restriction. See [Figure 7.3](#) for examples of top surface openings that reduce the risk of direct entry.

7.10.2 The 4.8 mm (3/16 inch) limitation does not apply for openings located 1.8 m (6 feet) or higher from the floor, when the unit is installed in accordance with the manufacturer's instructions. Such openings shall comply with the accessibility requirements in Protection of Users – Accessibility and User Servicing, Section [8](#).



## 7.11 Enclosures for wet and damp locations

### 7.11.1 General

7.11.1.1 All enclosures provided for units intended for use in wet and damp locations shall comply with the requirements in [7.11](#) or as an alternative, enclosures may be marked with a type rating suitable for use in wet and damp locations and shall comply with Annex [A](#), Ref. No. 19.

7.11.1.2 Units intended for use in wet and damp locations shall be evaluated for rain exposure in Section [7.11.2](#). If the unit makes use of gaskets or support feet to comply with the rain exposure, then the gaskets or support feet are evaluated in accordance with Section [7.11.3](#). If the polymeric enclosure makes use of metallic coatings for corrosion protection, the coating thickness is evaluated in accordance with Section [7.11.4](#).

### 7.11.2 Ingress protection

7.11.2.1 The unit shall comply with minimum Enclosure Type 3R rating in compliance with Annex [A](#), Ref. No. 19.

### 7.11.3 Gaskets

7.11.3.1 Gaskets depended upon for protection from environmental elements shall comply with Annex [A](#), Ref. No. 19.

### 7.11.4 Metallic coating thickness

7.11.4.1 With reference to Corrosion Protection, Section [11](#), a metallic coating with a specified thickness shall have that thickness verified through test.

7.11.4.2 The solution to be used for this test is to be made from distilled water and is to contain 200 grams per liter of reagent grade chromic acid ( $\text{CrO}_3$ ); and 50 grams per liter of reagent grade concentrated sulfuric acid ( $\text{H}_2\text{SO}_4$ ). The latter is equivalent to 27 milliliters of reagent grade concentrated sulfuric acid, specific gravity 1.84, containing 96 % of  $\text{H}_2\text{SO}_4$ .